

NREL's Experience with Aftermarket Conversions

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Presentation Overview

- Program objectives/basis
- Steps to high quality conversions
- Results
 - Meeting EPACT requirements
 - Evaluating performance
- Summary of conclusions

Objective

- Assist Federal government in meeting the alternative fuel vehicle purchase requirements of the Energy Policy Act (EPACT) of 1992
- Ensure high-quality equipment and installations
- Evaluate performance
 - Emissions tests
 - Driver surveys

Importance of Evaluating Aftermarket Conversions

- 330,000 on the road
- 10,000 conversions per year

Energy Policy Act of 1992

AFV Purchase Requirements

FY 1993	5,000
FY 1994	7,500
FY 1995	10,000
FY 1996	25%
FY 1997	33%
FY 1998	50%
FY 1999	75%

Typical annual Federal vehicle purchases

- 50,000 at the start of the program
- 35,000 after Federal downsizing

1992 OEM Vehicle Availability

Manufacturer	Model	Body Style	Fuel	Type
Chrysler-Dodge	Ram van/wagon	Full-size van	CNG	Dedicated
GM-Chevrolet	C1500/C2500	Full-size pickup	CNG	Bi-fuel
GM-Chevrolet	Lumina	Mid-size sedan	Ethanol	Flex-fuel
Ford	F700	Medium-duty truck	LPG	Dedicated

Two light-duty CNG models: one van and one pickup

Steps to High Quality Conversions

1. Conversion Company
2. Hardware Requirements (Equipment and Technology)
3. Installation Procedures
4. Warranty and Training
5. Emissions and Performance Requirements



Steps to High Quality Conversions

Conversion Company

- **Competitive Procurement/Evaluation Criteria**
 - **70% Technical Merit**
 - **30% Cost**

Hardware Requirements (Equipment and Technology)

Installation Procedures

Warranty and Training

Emissions and Performance Requirements



Steps to High Quality Conversions

Hardware Requirements (Equipment and Technology)

- **Closed loop feedback control**
- **AGA NGV2 Fuel cylinders - CNG**

Installation Procedures

Warranty and Training

Emissions and Performance Requirements

Conversion Company



Steps to High Quality Conversions

Installation Procedures

- **Best Industry Practice - NFPA Standards**
- **On-site inspection by NREL**

Warranty and Training

Emissions and Performance Requirements

Hardware Requirements (Equipment and Technology)

Conversion Company



Steps to High Quality Conversions

Warranty and Training

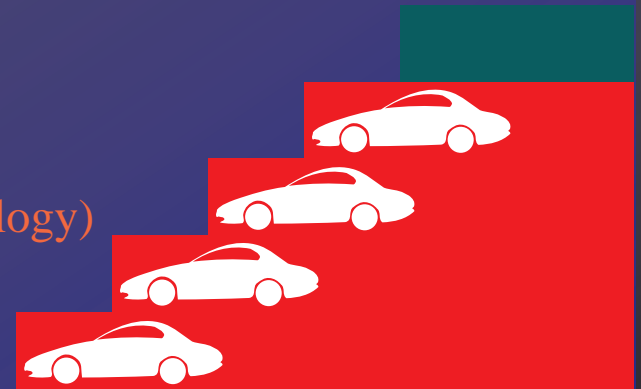
- **3 years/36,000 miles conversion system parts and labor**
- **Damages to OEM equipment**
- **Training site personnel**

Emissions and Performance Requirements

Installation Procedures

Hardware Requirements (Equipment and Technology)

Conversion Company



Steps to High Quality Conversions

Emissions and Performance Requirements

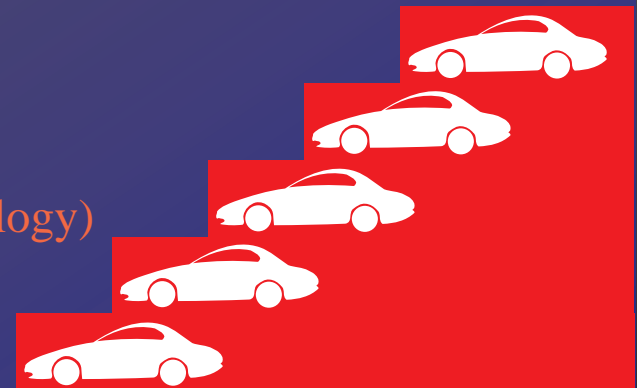
- **Applicable emissions standards (EPA/CARB)**
- **CNG range > 70 miles; LPG range > 170 miles**
- **Initial conversions test driven by NREL**
- **Emissions tests and driver surveys**

Warranty and Training

Installation Procedures

Hardware Requirements (Equipment and Technology)

Conversion Company



Results

880 High-Quality
Conversions in the
Federal Fleet



Results

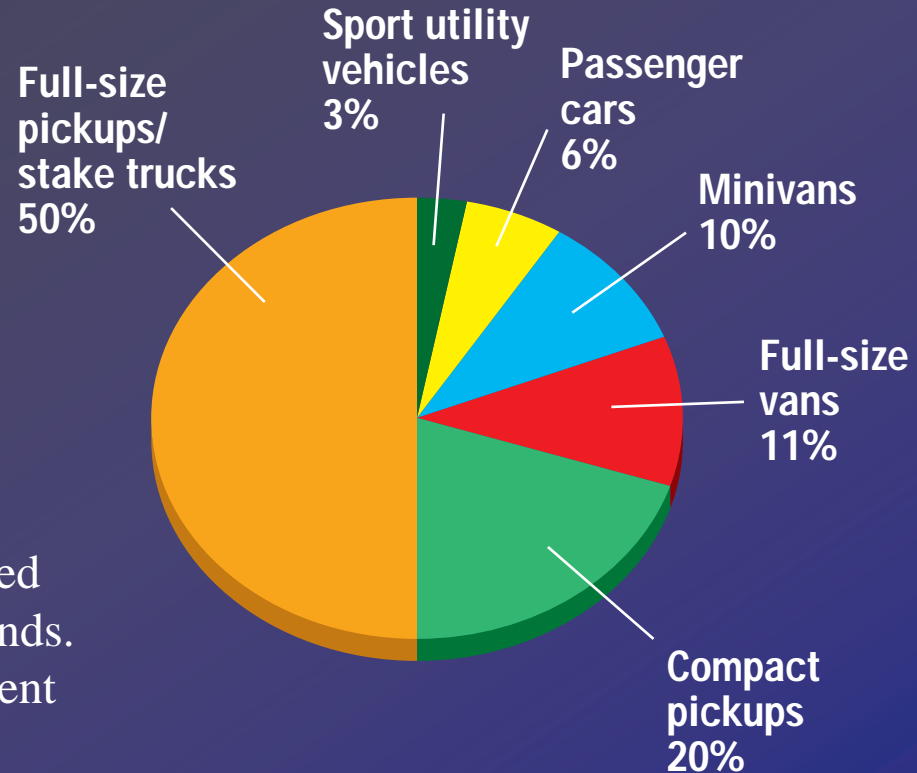
- Conversion Kit Selections
 - CNG: GFI and IMPCO kits
 - LPG: IMPCO ADP kits
- Average System Cost
 - CNG: \$4,500
 - LPG: \$2,800

Results

90 % Vans or Pickups

90% Bi-fuel

Note: Type of vehicles converted was based on fleet demands. They closely follow current OEM availability



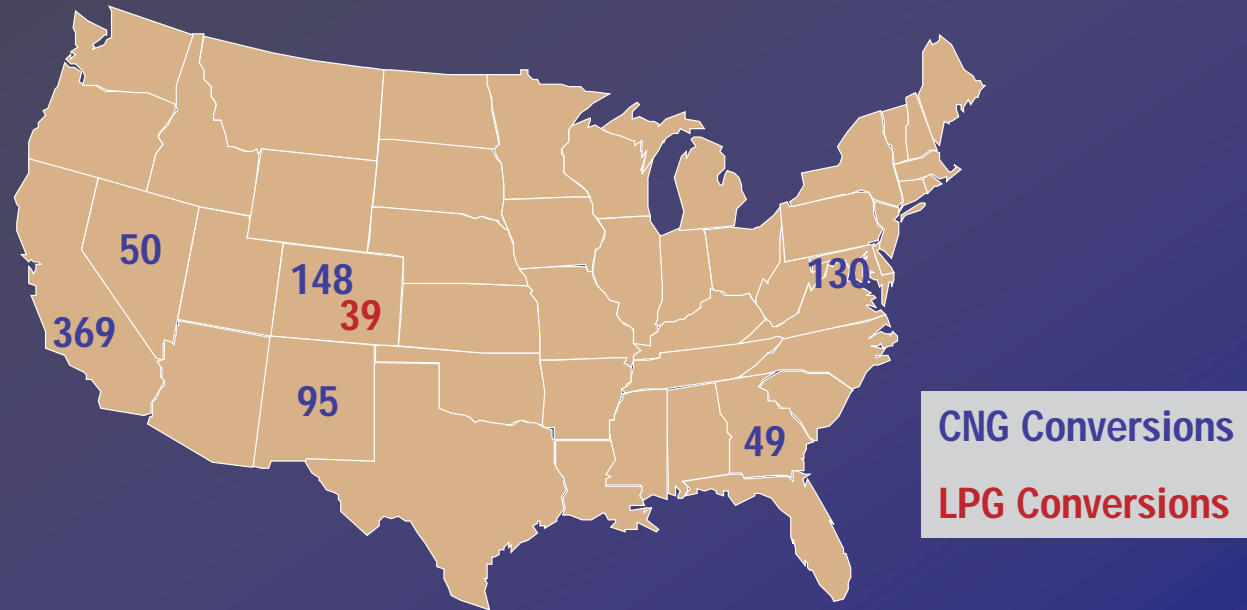
1996 OEM Vehicle Availability

Manufacturer	Model	Body Style	Fuel	Type
Chrysler-Dodge	Ram van/wagon	Full-size van	CNG	Dedicated
Chrysler-Dodge	Ram pickup	Full-size pickup	CNG	Dedicated
Chrysler-Dodge/ Plymouth	Caravan/Voyager	Minivan	CNG	Dedicated
Ford	Contour	Compact sedan	CNG	Bi-fuel
Ford	Taurus	Mid-size sedan	Methanol	Flex-fuel
Ford	Taurus	Mid-size sedan	Ethanol	Flex-fuel
Ford	Crown Victoria	Full-size sedan	CNG	Dedicated
Ford	F150/F250	Full-size pickup	CNG	Bi-fuel
Ford	Econoline	Full-size van	CNG	Bi-fuel
Ford	F150/F250	Full-size pickup	LPG	Bi-Fuel
Ford	F700	Medium-duty truck	LPG	Dedicated

Eight light-duty CNG/LPG models available

Results

Placement of CNG/LPG vehicles in six states
Including nine Clean Cities



Results

Variety of Federal Agencies

Agency	CNG	LPG	Total Vehicles
Air Force	368	0	368
Marines	219	0	219
Navy	97	0	97
National Institutes of Health	66	0	66
Forest Service	2	24	26
Other Federal Agencies	89	15	104
Totals	841	39	880

Emissions Testing

- Part of larger evaluation program
- 8 models/16 vehicles tested
- Specially blended test fuels
 - CNG—93% methane
 - LPG—HD5 transportation fuel
 - RFG—California Phase II reformulated gasoline
- EPA Federal Test Procedures
 - RFG before conversion
 - RFG shortly after conversion
 - CNG/LPG shortly after conversion

Emissions Results Legend



Large emissions decrease (>50%)



Moderate emissions decrease (10%–50%)

NC

No change (<10%)











































Moderate emissions increase (10%–50%)



Large emissions increase (>50%)















Emissions Results:

Washington, D.C. CNG Conversion Vehicles—Kit make: GFI

Vehicle Model	Model Year	After Conversion (RFG)			After Conversion (CNG)		
		NO _x	CO	NMHC	NO _x	CO	NMHC
Acclaim	1992	NC					
Acclaim	1992	NC		NC			
Astro	1992		NC	NC			
Caravan	1992						
Caravan	1992			NC			
Safari	1993	NC		NC		NC	
Safari	1993	NC					
Taurus	1994		NC				NC
Taurus	1994	NC					NC














Emissions Results:

Denver. CNG Conversion Vehicles—Kit make: GFI

Vehicle Model	Model Year	After Conversion (RFG)			After Conversion (CNG)		
		NO _x	CO	NMHC	NO _x	CO	NMHC
B250	1994	NC	NC	NC			
B250	1994		NC	NC			
C1500	1994	NC		NC			
C1500	1994	NC	NC	NC			

Emissions Results:

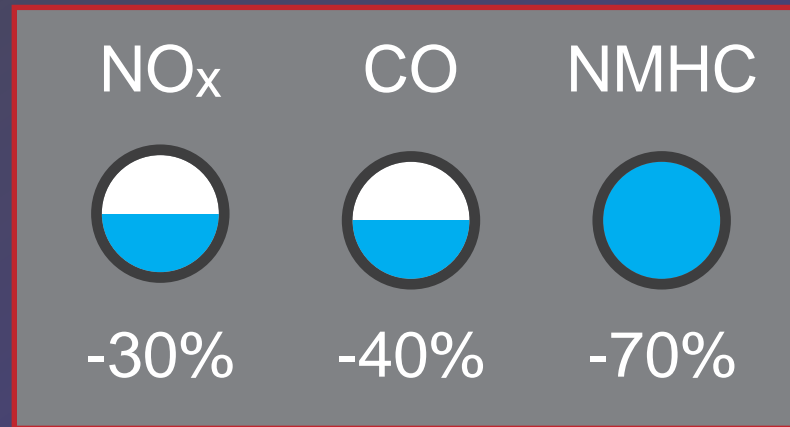
Denver LPG Conversion Vehicles—Kit make and model: IMPCO ADP

Vehicle Model	Model Year	After Conversion (RFG)			After Conversion (CNG)		
		NO _x	CO	NMHC	NO _x	CO	NMHC
F150 pkup	1994				NC		
F150 pkup	1994	NC			NC		
Taurus	1994	NC		NC			

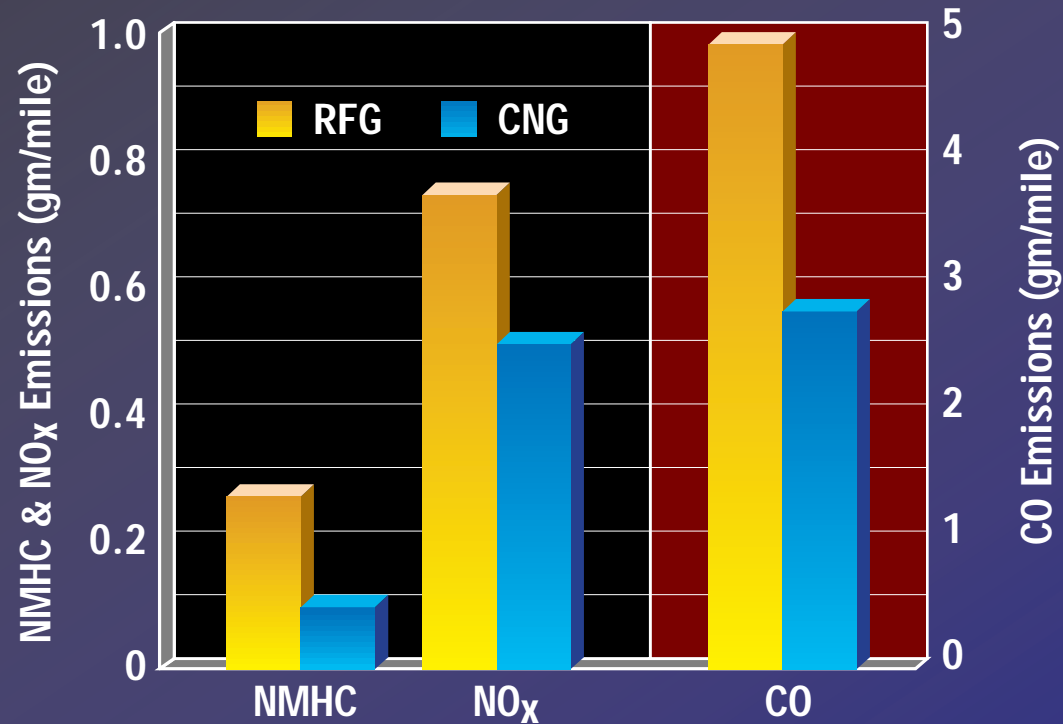
OEM Results: Dodge B250 Van

Dedicated CNG versus Standard Gasoline

Average of approximately 40 of each



OEM Results: Dodge B250 Van



Emissions Test Results - Other Considerations for Aftermarket Conversions

- Potential Positives
 - Ozone-forming potential
 - Exhaust toxics/particulate matter
 - Off-cycle emissions considerations
- Potential Negatives
 - Conversion of new, relatively clean (Tier 1) models
 - Use of less advanced kits (non-feedback)
 - Poor/untested installations
 - Deterioration

Conclusions

- Program was successful in helping to meet EPACT requirements
- Developed a systematic approach for fleets to ensure “high-quality” conversions
- Emissions results from conversions have raised some serious concerns
- OEM tests show emissions benefits “across the board”
- Fleets should require verification of emissions performance with FTP testing when considering aftermarket conversions
- Initial driver survey data are currently being tabulated